



EUROPEAN PATENT APPLICATION

(43) Date of publication:
20.09.2017 Bulletin 2017/38

(51) Int Cl.:
D03D 47/30 (2006.01)

(21) Application number: **17158313.1**

(22) Date of filing: **28.02.2017**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(71) Applicant: **Kabushiki Kaisha Toyota Jidoshokki
Kariya-shi, Aichi 448-8671 (JP)**

(72) Inventors:
• **MAKINO, Yoichi**
Kariya-shi, Aichi 448-8671 (JP)
• **OKUDA, Taijiro**
Kariya-shi, Aichi 448-8671 (JP)

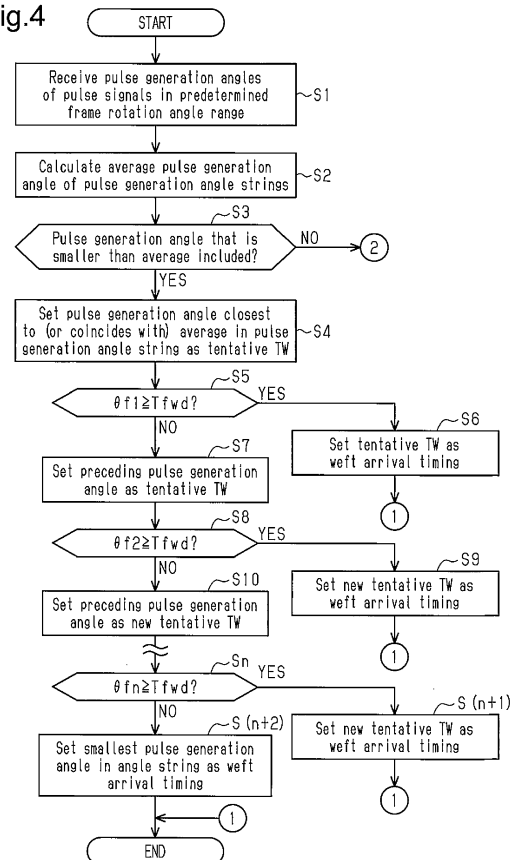
(30) Priority: **16.03.2016 JP 2016052236**

(74) Representative: **TBK**
Bavariaring 4-6
80336 München (DE)

(54) **WEFT DETECTION METHOD AND WEFT DETECTION DEVICE FOR JET LOOM**

(57) A CPU adds pulse generation angles to pulse signals input by a photoelectric detector and forms a pulse generation angle string with the pulse generation angles of the input pulse signals. The pulse generation angle string formed by the CPU for each pick is stored in a memory. The CPU also functions as an average weft arrival timing calculating means, a first tentative weft arrival timing setting means, a first weft arrival timing determining means, a second tentative weft arrival timing setting means, and a second weft arrival timing determining means.

Fig.4



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a weft detection method and weft detection device for a jet loom and, more particularly, to a weft detection method and a weft detection device that detect a weft arrival timing.

[0002] It is important that weft insertion be performed in a satisfactory manner when weaving high-quality fabric. In a jet loom, the weft needs to arrive at a predetermined weft insertion terminal position at a predetermined timing. In a predetermined period during a single frame rotation, the weft insertion timing corresponds to when the detection signal of a weft detector first exceeds a set value. However, the signals output from the weft detector may include a fiber dust signal or a noise signal in addition to a weft detection signal. Thus, a fiber dust signal or a noise signal may be output before a weft detection signal during the predetermined period. In such a case, the detected weft arrival timing will greatly differ from the actual weft arrival timing.

[0003] A weft insertion controller for a jet loom that is known in the art is configured to so that a fiber dust signal or a noise signal would not affect the weft arrival timing measurement accuracy. Japanese Laid-Open Patent Publication No. 4-24245 discloses a weft insertion controller including a photoelectric weft detector, which detects the arrival of a weft at a predetermined position, and a weft existence determining means. The weft existence determining means counts the input number of detection pulse signals from the weft detector and measures the input timing of each detection pulse signal. The weft insertion controller determines that a weft insertion timing has come when the input number of the detection pulse signals reaches a preset number (set number) in a predetermined period during a single frame rotation.

[0004] Signals generated by fiber dust or noise during each frame rotation have a tendency to occur in a relatively steady manner. Thus, prior to the actual weaving, the number of signals generated by fiber dust or noise is measured prior to the actual weaving to determine the set number. In the device disclosed in Japanese Laid-Open Patent Publication No. 4-24245, when there are an (N-1) number of pulse signals that are generated by fiber dust or noise before the weft arrival signal is generated, the Nth pulse signal will be the signal generated at the timing the weft arrives. For example, referring to Fig. 7A, when the number of pulse signals generated by fiber dust or noise is one, the pulse signal E2 generated before the weft arrival timing will be determined as not being a weft arrival signal. The pulse signal E1 at the head of the pulse string E generated after the pulse signal E2 will be determined as the pulse of the correct weft arrival timing. Referring to Fig. 7B, when the number of pulse signals generated by fiber dust or noise is two, the two pulse signals E2 generated before the weft arrival timing will be determined as not being a weft arrival sig-

nal. The pulse signal E1 at the head of the pulse string E generated after the two pulse signals E2 will be determined as the pulse of the correct weft arrival timing.

[0005] When a large amount of fiber dust results in the input of a large number of fiber dust signals, the actual weft arrival timing may be erroneously recognized. Thus, in a case in which pressure is used to control the weft arrival timing, a weft insertion error may occur if the weft insertion controller lowers the main air pressure too early when erroneously determining that the weft arrival timing has been reached. Further, in a case in which the amount of fiber dust is less than the set number, a timing that is later than the actual weft arrival may be recognized as the weft insertion timing.

SUMMARY OF THE INVENTION

[0006] It is an object of the present invention to provide a weft detection method and a weft detection device for a jet loom that allow for accurate detection of the weft arrival timing without being affected by the amount of fiber dust.

[0007] One aspect of the present invention is a weft detection method for a jet loom. The weft detection method detects a weft arrival angle from output pulses of a photoelectric weft detector that detects a weft. The method includes setting, when a pulse generation angle string of the output pulses of the photoelectric weft detector includes a pulse generation angle that is smaller than an average weft arrival timing, a pulse generation angle that is closest to the average weft arrival timing as a tentative weft arrival timing; comparing a difference between the tentative weft arrival timing and a pulse generation angle that precedes the tentative weft arrival timing with a first comparison value to set the tentative weft arrival timing as a weft arrival timing when the difference is greater than or equal to the first comparison value and set the pulse generation angle that precedes the tentative weft arrival timing as a new tentative weft arrival timing when the difference is less than the first comparison value; comparing a difference between the new tentative weft arrival timing and a pulse generation angle that precedes the new tentative weft arrival timing with the first comparison value to set the new tentative weft arrival timing as the weft arrival timing when the difference is greater than or equal to the first comparison value; repeating the series of the above steps until the difference between the new tentative weft arrival timing and the preceding pulse generation angle becomes greater than or equal to the first comparison value or the tentative weft arrival timing becomes the smallest pulse generation angle in the pulse generation angle string; setting, when the pulse generation angle string does not include a pulse generation angle that is smaller than the average weft arrival timing, a pulse generation angle that is larger than the average weft arrival timing and closest to the average weft arrival timing as a tentative weft arrival timing; comparing a difference between the tentative weft arrival tim-

ing and a pulse generation angle that follows the tentative weft arrival timing with a second comparison value to set the tentative weft arrival timing as the weft arrival timing when the difference is less than the second comparison value and set the pulse generation angle that follows the tentative weft arrival timing as a new tentative weft arrival timing when the difference is greater than or equal to the second comparison value; comparing a difference between the new tentative weft arrival timing and a pulse generation angle that follows the new tentative weft arrival timing with the second comparison value to set the new tentative weft arrival timing as the weft arrival timing when the difference is less than the second comparison value; and repeating the series of the above steps until the difference between the new tentative weft arrival timing and the following pulse generation angle becomes less than the second comparison value or until the tentative weft arrival timing becomes the largest pulse generation angle in the pulse generation string.

[0008] A further aspect of the present invention is a weft detection device for a jet loom that detects a weft arrival angle from output pulses of a photoelectric weft detector that detects a weft. The weft detection device includes a pulse generation adding means for adding pulse generation angles to pulse signals input by the photoelectric weft detector. A pulse generation angle string forming means forms a pulse generation angle string with the pulse generation angles of the input pulse signals. A pulse angle string storing means stores the pulse generation angle string for each pick. The weft detection device further includes an average weft arrival timing calculating means. A first tentative weft arrival timing setting means sets, when the pulse generation angle string stored in the pulse angle string storing means includes a pulse generation angle that is smaller than an average weft arrival timing, a pulse generation angle that is closest to the average weft arrival timing as a tentative weft arrival timing. A first weft timing determining means compares a difference between the tentative weft arrival timing set by the first tentative weft arrival timing setting means and a pulse generation angle that precedes the tentative weft arrival timing with a first comparison value, sets the tentative weft arrival timing as a weft arrival timing when the difference is greater than or equal to the first comparison value, sets the pulse generation angle that precedes the tentative weft arrival timing as a new tentative weft arrival timing when the difference is less than the first comparison value, compares a difference between the new tentative weft arrival timing and a pulse generation angle that precedes the new tentative weft arrival timing with the first comparison value, sets the new tentative weft arrival timing as the weft arrival timing when the difference is greater than or equal to the first comparison value, and repeats the series of the above steps until the difference between the new tentative weft arrival timing and the preceding pulse generation angle becomes greater than or equal to the first comparison value or the tentative weft arrival timing becomes the smallest pulse generation

angle in the pulse generation angle string. A second tentative weft arrival timing setting means sets, when the pulse generation angle string does not include a pulse generation angle that is smaller than the average weft arrival timing, a pulse generation angle that is larger than the average weft arrival timing and closest to the average weft arrival timing as the tentative weft arrival timing. A second weft arrival timing determining means compares a difference between the tentative weft arrival timing set by the second tentative weft arrival timing setting means and a pulse generation angle that follows the tentative weft arrival timing with a second comparison value, sets the tentative weft arrival timing as the weft arrival when the difference is less than the second comparison value, sets the pulse generation angle that follows the tentative weft arrival timing as a new tentative weft arrival timing when the difference is greater than or equal to the second comparison value, compares a difference between the new tentative weft arrival timing and a pulse generation angle that follows the new tentative weft arrival timing with the second comparison value, sets the new tentative weft arrival timing as the weft arrival timing when the difference is less than the second comparison value, and repeats the series of the above steps until the difference between the new tentative weft arrival timing and the following pulse generation angle becomes less than the second comparison value or until the tentative weft arrival timing becomes the largest pulse generation angle in the pulse generation string.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a schematic diagram of a weft insertion apparatus;
 Fig. 2 is a schematic diagram of a setting screen;
 Figs. 3A to 3C are schematic diagrams showing the operation of a weft arrival timing detection device;
 Fig. 4 is a flowchart showing the operation of the weft arrival timing detection device;
 Fig. 5 is a flowchart showing the operation of the weft arrival timing detection device;
 Fig. 6 is a table listing pulse generation angles for each pick; and
 Figs. 7A and 7B is a schematic diagrams illustrating the prior art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] One embodiment of an air-jet loom according to the present invention will now be described with reference to Figs. 1 to 6.

[0011] As shown in Fig. 1, a weft insertion apparatus 10 for an air-jet loom includes a weft storage 11, a weft main nozzle 12, a tandem nozzle 13 located at an upstream side of the main nozzle 12, weft insertion sub-nozzle groups 14A to 14F located at a downstream side of the main nozzle 12, and a reed 15. The reed 15 includes dents that are arranged next to one another in the weft insertion direction. Each dent includes a guide recess. The tandem nozzle 13 includes an ABS (automatic weft brake system) 16. The sub-nozzle groups 14A to 14F each include four sub-nozzles 14.

[0012] The weft storage 11 winds weft Y, which is fed from a weft cheese 17 that serves as a yarn feeder, around a length measurement drum 19. The weft storage 11 includes an engagement pin 20a that is driven by an electromagnetic solenoid 20 to engage and disengage the length measurement drum 19. The engagement and disengagement of the engagement pin 20a and the length measurement drum 19 controls the drawing of the weft Y from the length measurement drum 19. The length measurement drum 19 includes a photoelectric balloon sensor 21 that detects the balloon of the weft Y drawn from the length measurement drum 19. The balloon sensor 21 detects the balloon of the weft Y during weft insertion.

[0013] An air supply source 22 is connected by a pipe 23 and a regulator 24 to a main tank 25. The main tank 25 is connected by a pipe 23 and a main valve 26 to the main nozzle 12. The air supply source 22 is connected by a pipe 23 and a regulator 28 to a sub-tank 29. A controller C controls the main valve 26 and the tandem valve 27 to control the timing at which compressed air is ejected from the main nozzle 12 and the tandem nozzle 13. The air supply source 22 includes, for example, an air compressor.

[0014] The sub-tank 29 includes sub-valves 30, each connected by pipes 23 to corresponding ones of the sub-nozzle groups 14A to 14F. When each sub-valve 30 opens, compressed air is simultaneously ejected from the four sub-nozzles 14 of the corresponding one of the sub-nozzle groups 14A to 14F. The controller C controls the sub-valve 30 during weft insertion to control opening and closing of the sub-nozzle groups 14A to 14F so that the sub-nozzle groups 14A to 14F eject compressed air in a relayed manner at predetermined timings.

[0015] A weft feeler 31, which serves as a photoelectric weft detector that detects the weft Y, is located at the side of the reed 15 opposite to the main nozzle 12. The weft feeler 31 detects the end of the weft Y when the weft insertion of a single pick is completed. The weft feeler 31 outputs a pulse signal when detecting the weft Y and fiber dust.

[0016] The controller C includes a CPU 35 and a memory 36. The controller C controls the pressure of the main tank 25 with the regulator 24 and controls the pressure of the sub-tank 29 with the regulator 28. The controller C controls the opening and the closing of the main valve 26 and the tandem valve 27 to control the ejection timing

of compressed air from the main nozzle 12 and the tandem nozzle 13. The controller C controls the opening and closing of the sub-valves 30 to control the relayed ejection of compressed air from the sub-nozzle groups 14A to 14F.

[0017] The controller C configures a weft arrival timing detection device. The controller C receives an output pulse signal from the weft feeler 31 when the weft feeler 31 detects the weft Y. The controller C stores the input time of the output pulse signal as a frame angle. In detail, for each pulse received in a weft detection range, the CPU 35 adds a pulse generation angle that is the frame angle of the moment the pulse was generated. Further, the CPU 35 forms a string of the pulse generation angles. That is, the CPU 35 configures a pulse generation angle adding means and a pulse generation string forming means. The pulse generation angle string generated by the CPU 35 is stored in the memory 36. That is, the memory 36 configures a pulse angle string storing means. Further, the CPU 35 calculates weft arrival timings TW from the pulse generation angle strings and the average of the weft arrival timings TW. The CPU 35 configures an average weft arrival timing calculating means.

[0018] In this manner, the weft arrival timing detection device includes the pulse generation angle adding means, the pulse generation angle string forming means, the pulse angle string storing means, and the average weft arrival timing calculating means. When the pulse generation angle string stored in the memory 36 includes a pulse generation angle that is smaller than the average weft arrival timing, the CPU 35 sets the pulse generation angle that is closest to the average as a tentative weft arrival timing (tentative TW). The CPU 35 functions as a first tentative weft arrival timing setting means.

[0019] The CPU 35 compares the difference between the tentative weft arrival timing, which has been set by the first tentative weft arrival timing setting means, and the pulse generation angle that precedes the tentative weft arrival timing with a first comparison value (Tfwd). When the difference is greater than or equal to the first comparison value (Tfwd), the CPU 35 sets the tentative weft arrival timing as the weft arrival timing. When the difference is less than the first comparison value (Tfwd), the CPU 35 sets the pulse generation angle preceding the tentative weft arrival timing as a new tentative weft arrival timing. Then, the CPU 35 compares the difference between the new weft arrival timing and the pulse generation angle that precedes the new tentative weft arrival timing with the first comparison value (Tfwd). When the difference is greater than or equal to the first comparison value (Tfwd), the CPU 35 sets the new tentative weft arrival timing as the weft arrival timing. The CPU 35 repeats the series of the steps described above until the difference between the new tentative weft arrival timing and the pulse generation angle preceding the new tentative weft arrival timing becomes greater than or equal to the first comparison value (Tfwd) or the tentative weft arrival timing becomes the largest pulse generation angle

in the pulse generation angle string. The CPU 35 functions as a first weft arrival timing determining means.

[0020] When the pulse generation angle string does not include any pulse generation angle that is smaller than average weft arrival timing, the CPU 35 sets the pulse generation angle that is larger than the average and closest to the average as a tentative weft arrival timing. The CPU 35 functions as a second tentative weft arrival timing setting means.

[0021] The CPU 35 compares the difference between the tentative weft arrival timing, which has been set by the second tentative weft arrival timing setting means, and the pulse generation angle following the tentative weft arrival timing, with a second comparison value (Trea). When the difference is less than the second comparison value (Trea), the CPU 35 sets the tentative weft arrival timing as the weft arrival timing. When the difference is greater than or equal to the second comparison value (Trea), the CPU 35 sets the pulse generation angle following the tentative weft arrival timing as a new tentative weft arrival timing. The CPU 35 compares the difference between the new tentative weft arrival timing and the pulse generation angle following the new tentative weft arrival timing with the second comparison value (Trea). When the difference is less than the second comparison value (Trea), the CPU 35 sets the new tentative weft arrival timing as the weft arrival timing. The CPU 35 repeats the series of the steps described above until the difference between the new tentative weft arrival timing and the pulse generation angle following the new tentative weft arrival timing becomes less than the second comparison value (Trea) or the tentative weft arrival timing becomes the largest pulse generation angle in the pulse generation angle string. The CPU 35 functions as a second weft arrival timing determining means.

[0022] In this manner, the controller C, which configures the weft arrival timing detection device, includes the first tentative weft arrival timing setting means, the first weft arrival timing determining means, the second tentative weft arrival timing setting means, and the second weft arrival timing determining means.

[0023] The controller C is connected to a function panel 40 that serves as an input-output device. The function panel 40 includes a display 41 and input keys. The display 41 shows a setting screen 42 that is illustrated in Fig. 2.

[0024] As shown in Fig. 2, the setting screen 42 includes a weft detection range setting portion 44, a first comparison value setting portion 45, a second comparison value setting portion 46, and yarn detection pulse number setting portions 47. The weft detection range setting portion 44 is used to set the weft detection range in which the controller C detects (calculates) the weft arrival timing. The first comparison value setting portion 45 is used to set the first comparison value (Tfwd). The second comparison value setting portion 46 is used to set the second comparison value (Trea). Each yarn detection pulse number setting portion 47 is used to set the minimum pulse number for determining the existence of the

weft Y in the weft detection range. Fig. 2 shows an example in which the minimum frame angle of the weft detection range is 220° and the maximum frame angle of the weft detection range is 310°.

[0025] The operation of the weft arrival timing detection device will now be described.

[0026] First, the weft detection range, the first comparison value Tfwd, the second comparison value Trea, and the yarn detection pulse number are set. For example, as shown in Fig. 2, the operator inputs the values of the weft detection range, the first comparison value Tfwd, the second comparison value Trea, and the yarn detection pulse number to the setting screen 42 in the display 41 of the function panel 40. More specifically, the first comparison value Tfwd and the second comparison value Trea are each set to 5°. The first comparison value Tfwd and the second comparison value Trea are measured by operating the loom in advance before performing the actual weaving operation. Under this situation, the operator operates a weft arrival timing detection start switch (not shown) so that the controller C starts the weft arrival timing detection.

[0027] The controller C detects the weft arrival timing in accordance with the flowchart of Figs. 4 and 5.

[0028] In step S1, the pulse generation angles of pulse signals in a frame angle range (220° to 310°), which is set in advance, are input to the controller C. Based on the pulse generation angles of the input pulse signals, the controller C forms a pulse generation angle string and stores the pulse generation angle string for each pick in the memory 36.

[0029] In step S2, the controller C calculates the average weft arrival timing. Further, a table such as that illustrated in Fig. 6 is generated. The table lists the pulse generation angles at which the existence of the weft was determined. The data of the table and the average of the weft arrival timings are periodically updated.

[0030] In step S3, the controller C determines whether or not a pulse generation angle that is smaller than the average weft arrival timing is included in the pulse generation angle string. When a pulse generation angle that is smaller than the average weft arrival timing is included, the controller C proceeds to step S4.

[0031] In step S4, the controller C refers to the table and sets the pulse generation angle that is closest to (or coincides with) the average weft arrival timing as the tentative weft arrival timing (tentative TW). That is, the controller C sets the tentative weft arrival timing to the pulse generation angle of which the difference from the average weft arrival timing is the smallest.

[0032] In step S5, the controller C compares the difference $\theta f1$ between the tentative weft arrival timing (tentative TW) and the pulse generation angle preceding the tentative weft arrival timing with the first comparison value Tfwd, which is set in advance. When the difference $\theta f1$ is greater than or equal to the first comparison value Tfwd, the controller C proceeds to step S6 and sets the tentative weft arrival timing (tentative TW) as the weft

arrival timing.

[0033] When the difference $\theta f1$ is less than the first comparison value $Tfwd$ in step S5, the controller C proceeds to step S7 and sets the preceding pulse generation angle as a new tentative weft arrival timing (tentative TW). Then, in step S8, the controller C compares the difference $\theta f2$ between the new tentative weft arrival timing (tentative TW) and the pulse generation angle preceding the new tentative weft arrival timing with the first comparison value $Tfwd$.

[0034] When the difference $\theta f2$ is greater than or equal to the first comparison value $Tfwd$ in step S8, the controller C proceeds to step S9 and sets the new tentative weft arrival timing (tentative TW) as the weft arrival timing. When the difference $\theta f2$ is less than the first comparison value $Tfwd$ in step S8, the controller C proceeds to step S10 and sets the preceding pulse generation angle as a new tentative weft arrival timing (tentative TW). Then, the controller C proceeds to the next step and repeats the same steps until the difference θfn between the new tentative weft arrival timing (tentative TW) and the pulse generation angle preceding the new tentative weft arrival timing becomes greater than or equal to the first comparison value $Tfwd$ or until the tentative weft arrival timing becomes the smallest pulse generation angle in the pulse generation angle string. In step S_n , when the difference θfn between the new tentative weft arrival timing (tentative TW) and the preceding pulse becomes greater than or equal to the first comparison value $Tfwd$, the controller C proceeds to step $S(n+1)$ and sets the new tentative weft arrival timing (tentative TW) as the weft arrival timing. When the tentative weft arrival timing (tentative TW) becomes the smallest pulse generation angle in the pulse generation angle string, the controller C proceeds to step $S(n+2)$ and sets the tentative weft arrival timing (tentative TW) as the weft arrival timing.

[0035] In step S3, when the pulse generation angle string does not include a pulse generation angle that is smaller than the average weft arrival timing, the controller C proceeds to step $S(n+3)$ and sets the pulse generation angle that is closest to (or coincides with) the average weft arrival timing as the tentative weft arrival timing (tentative TW). That is, the controller C sets the tentative weft arrival timing to the pulse generation angle of which the difference from the average weft arrival timing is the smallest. Then, the controller C proceeds to step $S(n+4)$ and compares the difference $\theta r1$ between the tentative weft arrival timing (tentative TW) and the pulse generation angle following the tentative weft arrival timing with the second comparison value $Trea$, which is set in advance. When the difference $\theta r1$ is less than the second comparison value $Trea$, the controller C proceeds to step $S(n+5)$ and sets the tentative weft arrival timing (tentative TW) as the weft arrival timing. When the difference $\theta r1$ is greater than or equal to the second comparison value $Trea$ in step $S(n+4)$, the controller C proceeds to step $S(n+6)$ and sets the following pulse generation angle as a new tentative weft arrival timing (tentative TW). Then,

in step $S(n+7)$, the controller C compares the difference $\theta r2$ between the new tentative weft arrival timing (tentative TW) and the pulse generation angle following the new tentative weft arrival timing with the second comparison value $Trea$. When the difference $\theta r2$ is less than the second comparison value $Trea$, the controller C proceeds to step $S(n+8)$ and sets a new tentative weft arrival timing (tentative TW) as the weft arrival timing. When the difference $\theta r2$ is greater than or equal to the second comparison value $Trea$ in step $S(n+7)$, the controller C proceeds to step $S(n+9)$ and sets the following pulse generation angle as the tentative weft arrival timing (tentative TW). Then, the controller C proceeds to the next step and repeats the same steps until the difference θrn between the new tentative weft arrival timing (tentative TW) and the pulse generation angle following the new tentative weft arrival timing becomes greater than or equal to the second comparison value $Trea$ or until the tentative weft arrival timing becomes the largest, or final, pulse generation angle in the pulse generation angle string. In step $S(2n)$, when the difference θrn between the new tentative weft arrival timing (tentative TW) and the following pulse generation angle becomes less than the second comparison value $Trea$, the controller C proceeds to step $S(2n+1)$ and sets the new tentative weft arrival timing (tentative TW) as the weft arrival timing. When the tentative weft arrival timing (tentative TW) becomes the largest, or final, pulse generation angle in the pulse generation angle string in step $S(2n)$, the controller C proceeds to step $S(2n+2)$ and sets the tentative weft arrival timing (tentative TW) as the weft arrival timing (TW).

[0036] Fig. 3A shows an example in which pulse signals exist before and after the average weft arrival timing (average TW), and the intervals $d1$ and $d2$ between three pulse generation angles $P1$, $P2$, and $P3$ that are smaller than the average TW are each smaller than the first comparison value $Tfwd$. In this case, the pulse generation angle $P1$ is the closest to the average weft arrival timing and smaller than the average weft arrival timing. Thus, the pulse generation angle $P1$ is set as the tentative TW, the interval $d1$ between the pulse generation angles $P1$ and $P2$ correspond to the difference $\theta f1$ of the flowchart, and the interval $d2$ between the pulse generation angles $P2$ and $P3$ correspond to the difference $\theta f2$ of the flowchart. Further, in this case, in step S5 of the flowchart, the difference $\theta f1$ is not greater than or equal to the first comparison value $Tfwd$. Thus, the controller C proceeds to step S7 and sets the pulse generation angle $P2$ as the tentative TW. Then, in step S8, the controller C compares the difference $\theta f2$ between the pulse generation angles $P2$ and $P3$ with the first comparison value $Tfwd$. In this case, the difference $\theta f2$ is not greater than or equal to the first comparison value $Tfwd$. Thus, the controller C proceeds to the next step. However, there is no pulse signal ahead of the pulse generation angle $P3$. Thus, the pulse generation angle $P3$ is set as the weft arrival timing.

[0037] Fig. 3B shows an example in which pulse signals exist before and after the average weft arrival timing

(average TW). Further, among the intervals d1 and d2' between the three pulse generation angles P1, P2, and P3 that are smaller than the average TW, the interval d1 is smaller than the first comparison value T_{fwd} and the interval d2' is larger than the first comparison value T_{fwd}. In this case, the pulse generation angle P1 is the closest to the average weft arrival timing and smaller than the average weft arrival timing. Thus, the pulse generation angle P1 is set as the tentative TW. Further, in this case, in step S5 of the flowchart, the interval d1, or the difference $\theta f1$, is not greater than or equal to the first comparison value T_{fwd}. Thus, the controller C proceeds to step S7 and sets the pulse generation angle P2 as the tentative TW. Then, the controller C proceeds to step S8 and compares the interval d2', or the difference $\theta f2$, between the pulse generation angles P2 and P3 with the first comparison value T_{fwd}. In this case, the difference $\theta f2$ is greater than or equal to the first comparison value T_{fwd}. Thus, the controller C proceeds to step S9 and sets the pulse generation angle P2 as the weft arrival timing.

[0038] Fig. 3C shows an example in which there are three pulse generation angles P1, P2, and P3 that are larger than the average TW. Further, among the intervals d1' and d2 of the three pulse generation angles P1, P2, and P3, the interval d1' is larger than the second comparison value T_{rea}, and the interval d2 is smaller than the second comparison value T_{rea}. In this case, there are no pulse generation angles that are smaller than the average weft arrival timing. Thus, in step S(n+3) of the flowchart, the controller C sets the pulse generation angle P1 as the tentative TW. Then, in step S(n+4), the controller C compares the difference $\theta r1$ between the tentative TW and the pulse generation angle P2 following the tentative TW with the second comparison value T_{rea}. In this case, the difference $\theta r1$ is not less than the second comparison value T_{rea}. Thus, the controller C proceeds to step S(n+6) and sets the pulse generation angle P2 as the new tentative TW. Then, in step S(n+7), the controller C compares the difference $\theta r2$ between the pulse generation angles P2 and P3 with the second comparison value T_{rea}. The difference $\theta r2$ is less than the second comparison value T_{rea}. Thus, the controller C proceeds to step S(n+8) and sets the pulse generation angle P2 as the weft arrival timing.

[0039] The detection of the weft arrival timing will now be described with reference to the table of Fig. 6. The table shows the pulse generation angles where the existence of a weft was determined and the pulse generation angle string of each pick. The detection range is the frame angle from 210° to 310°. The average TW is 244°, the first comparison value T_{fwd} is 5°, and the second comparison value T_{rea} is 5°.

[0040] For example, in pick No. 3, a pulse generation angle that is ahead of (smaller than) the average of 244° is located. In this case, the pulse generation angle of 242° is set as a candidate for the weft arrival timing (TW). In other words, 242° is set as the tentative weft arrival timing. There are no pulse signals ahead of 242°. Thus,

242° is set as the weft arrival timing (TW).

[0041] In pick No. 15, the pulse generation angle of 243° is ahead of (smaller than) the average of 244°. Thus, 243° is set as a candidate for the weft arrival timing (TW). That is, 243° is set as the tentative weft arrival timing. Further, the pulse generation angle of 219° is ahead of 243°. However, 219° is separated by 5° or greater from 243°. Thus, 243° is set as the weft arrival timing (TW).

[0042] In pick No. 1, there are no pulse generation angles that are ahead of (smaller than) the average value of 244°. Thus, a pulse generation angle that is behind (larger than) the average value of 244° is located. In this case, the pulse generation angle of 250° is set as a candidate for the weft arrival timing (TW). In other words, 250° is set as the tentative weft arrival timing. Further, the pulse generation angle of 254° is behind 250°. However, 254° is not separated by 5° or greater from 250°. Thus, 250° is set as the weft arrival timing (TW).

[0043] In the pulse generation angle strings for the other picks, the weft arrival timing (TW) is located in the same manner. Consequently, the shaded pulse generation angles in Fig. 6 are set as the weft arrival timings (TW).

[0044] The above embodiment has the advantages described below.

(1) In the weft detection method described above, when the pulse generation angle string of the output pulses from the weft feeler 31 includes pulse generation angles that are smaller than the average weft arrival timing, the CPU 35 sets the pulse generation angle of which the difference from the average is the smallest as the tentative weft arrival timing. Then, the CPU 35 compares the difference between the tentative weft arrival timing and the preceding pulse generation angle with the first comparison value. When the difference is greater than or equal to the first comparison value, the CPU 35 sets the tentative weft arrival timing as the weft arrival timing. When the difference is less than the first comparison value, the CPU 35 sets the pulse generation angle preceding the tentative weft arrival timing as a new tentative weft arrival timing. Then, the CPU 35 compares the difference between the new tentative weft arrival timing and the preceding pulse generation angle with the first comparison value. When the difference is greater than or equal to the first comparison value, the CPU 35 sets the new tentative weft arrival timing as the weft arrival timing. The CPU 35 repeats the series of steps described above until the difference between the new tentative weft arrival timing and the preceding pulse generation angle becomes greater than or equal to the first comparison value or the tentative weft arrival timing becomes the smallest pulse generation angle in the pulse generation angle string.

When the pulse generation string does not include any pulse generation angles that are smaller than

the average weft arrival timing, the CPU 35 sets the pulse generation angle that is larger than the average and closest to the average as the tentative weft arrival timing. Then, the CPU 35 compares the difference between the tentative weft arrival timing and the following pulse generation angle with the second comparison value. When the difference is less than the second comparison value, the CPU 35 sets the tentative weft arrival timing as the weft arrival timing. When the difference is greater than or equal to the second comparison value, the CPU 35 sets the pulse generation angle following the tentative weft arrival timing as a new tentative weft arrival timing. Then, the CPU 35 compares the difference between the new tentative weft arrival timing and the following pulse generation angle with the second comparison value. When the difference is less than the second comparison value, the CPU 35 sets the new tentative weft arrival timing as the weft arrival timing. The CPU 35 repeats the series of steps described above until the difference between the new tentative weft arrival timing and the following pulse generation angle becomes less than the second comparison value or the tentative weft arrival timing becomes the largest pulse generation angle in the pulse generation angle string. This configuration allows the accurate weft arrival timing to be accurately detected without being affected by the amount of fiber dust.

(2) In the jet loom, the weft detection device uses the output pulses of the weft feeler 31 to detect the weft arrival angle. The weft detection device includes the pulse generation angle adding means, the pulse angle string forming means, the pulse angle string storing means, and the average weft arrival timing calculating means. The pulse generation angle adding means adds pulse generation angles to pulse signals input by the photoelectric weft detector. The pulse generation angle string forming means forms a pulse generation angle string with the pulse generation angles of the input pulse signals. The pulse angle string storing means stores the pulse generation angle string for each pick. Further, the weft detection device includes the first tentative weft arrival timing setting means and the first weft arrival timing determining means. In a case in which a pulse generation string stored in the pulse angle string storing means includes a pulse generation angle that is smaller than the average weft arrival timing, the first tentative weft arrival timing sets the pulse generation angle that is closest to the average as a tentative weft arrival timing. The first weft arrival timing determining means compares the difference between the tentative weft arrival timing, which is set by the first tentative weft arrival timing, and the pulse generation angle preceding the tentative weft arrival timing with a first comparison value. When the difference is greater than or equal to the first comparison value, the first weft arrival timing determining means sets

the tentative weft arrival timing as the weft arrival timing. When the difference is less than the first comparison value, the first weft arrival timing determining means sets the pulse generation angle preceding the tentative weft arrival timing as a new tentative weft arrival timing. Then, the first weft arrival timing determining means compares the difference between the new tentative weft arrival timing and the pulse generation angle preceding the new tentative weft arrival timing. When the difference is greater than or equal to the first comparison value, the first weft arrival timing determining means sets the new tentative weft arrival timing as the weft arrival timing. The first weft arrival timing determining means repeats the series of steps described above until the difference between the new tentative weft arrival timing and the preceding pulse generation angle becomes greater than or equal to the first comparison value or the tentative weft arrival timing becomes the smallest pulse generation angle in the pulse generation angle string.

Further, the weft detection device includes a second tentative weft arrival timing setting means and a second weft arrival timing determining means. In a case in which a pulse generation angle string does not include any pulse generation angles that are smaller than the average, the second tentative weft arrival timing setting means sets the pulse generation angle that is larger than the average and closest to the average as the tentative weft arrival timing. The second weft arrival timing determining means compares the difference between the tentative weft arrival timing, which is set by second tentative weft arrival timing setting means, and the pulse generation angle following the tentative weft arrival timing with the second comparison value. When the difference is less than the second comparison value, the second weft arrival timing determining means sets the tentative weft arrival timing as the weft arrival timing. When the difference is greater than or equal to the second comparison value, the second weft arrival timing determining means sets the pulse generation angle following the tentative weft arrival timing as a new tentative weft arrival timing. Then, the second weft arrival timing determining means compares the difference between the new tentative weft arrival timing and the following pulse generation angle with the second comparison value. When the difference is less than the second comparison value, the second weft arrival timing determining means sets the new tentative weft arrival timing as the weft arrival timing. The second weft arrival determining means repeats the series of steps described above until the difference between the new tentative weft arrival timing and the following pulse generation angle becomes less than the second comparison value or the tentative weft arrival timing becomes the largest pulse generation angle in the pulse generation angle

string.

The configuration allows the weft detection method to be implemented. Thus, the accurate weft arrival timing may be accurately detected regardless of the amount of fiber dust.

(3) The weft detection device includes the first comparison value setting portion 45, which sets the first comparison value Tfwd, and the second comparison value setting portion 46, which sets the second comparison value Trea. Values that are set in advance may be used as the first comparison value Tfwd and the second comparison value Trea. However, when the weft detection device includes the first comparison value setting portion 45 and the second comparison value setting portion 46, the first comparison value Tfwd and the second comparison value Trea may be set to be suitable for the weaving conditions.

(4) The weft detection device includes the setting screen 42 used to show and set the first comparison value Tfwd and the second comparison value Trea, which are set with the first comparison value setting portion 45 and the second comparison value setting portion 46. As long as the setting screen 42 allows the set values to be input, the setting screen 42 does not have to show the set values. However, the operator will be able to check the set values by showing the set values on the setting screen 42. This reduces erroneous inputs.

[0045] The above embodiment may be modified as described below.

[0046] The setting screen 42 that shows the first comparison value Tfwd and the second comparison value Trea set by the first comparison value setting portion 45 and the second comparison value setting portion 46 may be omitted. However, the operator will be able to easily check the set values by showing the set values on the setting screen 42. This reduces erroneous inputs.

[0047] The first comparison value Tfwd and the second comparison value Trea does not necessarily have to be input by the operator. For example, the memory 36 of the controller C may store a plurality of first comparison values Tfwd and second comparison values Trea in correspondence with weaving conditions. In this case, the controller C automatically sets the first comparison value Tfwd and the second comparison value Trea that is suitable for the weaving conditions.

[0048] The weft arrival timing does not have to be detected through a process that uses pulses to detect a weft and may be applied to a process that integrates yarn signals to detect a weft.

[0049] The tandem nozzle 13 may be omitted.

[0050] A CPU adds pulse generation angles to pulse signals input by a photoelectric detector and forms a pulse generation angle string with the pulse generation angles of the input pulse signals. The pulse generation angle string formed by the CPU for each pick is stored in a memory. The CPU also functions as an average weft

arrival timing calculating means, a first tentative weft arrival timing setting means, a first weft arrival timing determining means, a second tentative weft arrival timing setting means, and a second weft arrival timing determining means.

Claims

1. A weft detection method for a jet loom, wherein the weft detection method detects a weft arrival angle from output pulses of a photoelectric weft detector (31) that detects a weft (Y), the method comprising:

setting, when a pulse generation angle string of the output pulses of the photoelectric weft detector (31) includes a pulse generation angle (P1, P2, P3) that is smaller than an average weft arrival timing (TW), a pulse generation angle (P1, P2, P3) that is closest to the average weft arrival timing (TW) as a tentative weft arrival timing (TW);

comparing a difference between the tentative weft arrival timing (TW) and a pulse generation angle (P1, P2, P3) that precedes the tentative weft arrival timing (TW) with a first comparison value (Tfwd) to set the tentative weft arrival timing (TW) as a weft arrival timing when the difference is greater than or equal to the first comparison value (Tfwd) and set the pulse generation angle (P1, P2, P3) that precedes the tentative weft arrival timing (TW) as a new tentative weft arrival timing (TW) when the difference is less than the first comparison value (Tfwd);

comparing a difference between the new tentative weft arrival timing (TW) and a pulse generation angle (P1, P2, P3) that precedes the new tentative weft arrival timing (TW) with the first comparison value (Tfwd) to set the new tentative weft arrival timing (TW) as the weft arrival timing when the difference is greater than or equal to the first comparison value (Tfwd);

repeating the series of the above steps until the difference between the new tentative weft arrival timing (TW) and the preceding pulse generation angle (P1, P2, P3) becomes greater than or equal to the first comparison value (Tfwd) or the tentative weft arrival timing (TW) becomes the smallest pulse generation angle (P1, P2, P3) in the pulse generation angle string;

setting, when the pulse generation angle string does not include a pulse generation angle (P1, P2, P3) that is smaller than the average weft arrival timing (TW), a pulse generation angle (P1, P2, P3) that is larger than the average weft arrival timing (TW) and closest to the average weft arrival timing (TW) as a tentative weft arrival timing (TW);

- comparing a difference between the tentative weft arrival timing (TW) and a pulse generation angle (P1, P2, P3) that follows the tentative weft arrival timing (TW) with a second comparison value (Trea) to set the tentative weft arrival timing (TW) as the weft arrival timing when the difference is less than the second comparison value (Trea) and set the pulse generation angle (P1, P2, P3) that follows the tentative weft arrival timing (TW) as a new tentative weft arrival timing (TW) when the difference is greater than or equal to the second comparison value (Trea); comparing a difference between the new tentative weft arrival timing (TW) and a pulse generation angle (P1, P2, P3) that follows the new tentative weft arrival timing (TW) with the second comparison value (Trea) to set the new tentative weft arrival timing (TW) as the weft arrival timing when the difference is less than the second comparison value (Trea); and repeating the series of the above steps until the difference between the new tentative weft arrival timing (TW) and the following pulse generation angle (P1, P2, P3) becomes less than the second comparison value (Trea) or until the tentative weft arrival timing (TW) becomes the largest pulse generation angle (P1, P2, P3) in the pulse generation string.
2. A weft detection device for a jet loom that detects a weft arrival angle from output pulses of a photoelectric weft detector (31) that detects a weft (Y), the weft detection device comprising:
- a pulse generation adding means (35) for adding pulse generation angles (P1, P2, P3) to pulse signals input by the photoelectric weft detector (31);
 - a pulse generation angle string forming means (35) for forming a pulse generation angle string with the pulse generation angles (P1, P2, P3) of the input pulse signals;
 - a pulse angle string storing means (36) for storing the pulse generation angle string for each pick;
 - an average weft arrival timing calculating means (35);
 - a first tentative weft arrival timing setting means (35) for setting, when the pulse generation angle string stored in the pulse angle string storing means (36) includes a pulse generation angle (P1, P2, P3) that is smaller than an average weft arrival timing (TW), a pulse generation angle (P1, P2, P3) that is closest to the average weft arrival timing (TW) as a tentative weft arrival timing (TW);
 - a first weft timing determining means (35) for comparing a difference between the tentative

weft arrival timing (TW) set by the first tentative weft arrival timing setting means (35) and a pulse generation angle (P1, P2, P3) that precedes the tentative weft arrival timing (TW) with a first comparison value (Tfwd), setting the tentative weft arrival timing (TW) as a weft arrival timing when the difference is greater than or equal to the first comparison value (Tfwd), setting the pulse generation angle (P1, P2, P3) that precedes the tentative weft arrival timing (TW) as a new tentative weft arrival timing (TW) when the difference is less than the first comparison value (Tfwd), comparing a difference between the new tentative weft arrival timing (TW) and a pulse generation angle (P1, P2, P3) that precedes the new tentative weft arrival timing (TW) with the first comparison value (Tfwd), setting the new tentative weft arrival timing (TW) as the weft arrival timing when the difference is greater than or equal to the first comparison value (Tfwd), and repeating the series of the above steps until the difference between the new tentative weft arrival timing (TW) and the preceding pulse generation angle (P1, P2, P3) becomes greater than or equal to the first comparison value (Tfwd) or the tentative weft arrival timing (TW) becomes the smallest pulse generation angle (P1, P2, P3) in the pulse generation angle string; a second tentative weft arrival timing setting means (35) for setting, when the pulse generation angle string does not include a pulse generation angle (P1, P2, P3) that is smaller than the average weft arrival timing (TW), a pulse generation angle (P1, P2, P3) that is larger than the average weft arrival timing (TW) and closest to the average weft arrival timing (TW) as the tentative weft arrival timing (TW); and a second weft arrival timing determining means (35) for comparing a difference between the tentative weft arrival timing (TW) set by the second tentative weft arrival timing setting means (35) and a pulse generation angle (P1, P2, P3) that follows the tentative weft arrival timing (TW) with a second comparison value (Trea), setting the tentative weft arrival timing (TW) as the weft arrival when the difference is less than the second comparison value (Trea), setting the pulse generation angle (P1, P2, P3) that follows the tentative weft arrival timing (TW) as a new tentative weft arrival timing (TW) when the difference is greater than or equal to the second comparison value (Trea), comparing a difference between the new tentative weft arrival timing (TW) and a pulse generation angle (P1, P2, P3) that follows the new tentative weft arrival timing (TW) with the second comparison value (Trea), setting the new tentative weft arrival timing (TW) as the weft arrival timing when the difference is less than

the second comparison value (Trea), and repeating the series of the above steps until the difference between the new tentative weft arrival timing (TW) and the following pulse generation angle (P1, P2, P3) becomes less than the second comparison value (Trea) or until the tentative weft arrival timing (TW) becomes the largest pulse generation angle (P1, P2, P3) in the pulse generation string.

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3. The weft detection device for a jet loom according to claim 2, further comprising a setting portion (45, 46) for setting the first comparison value (Tfwd) and the second comparison value (Trea).

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Fig.1

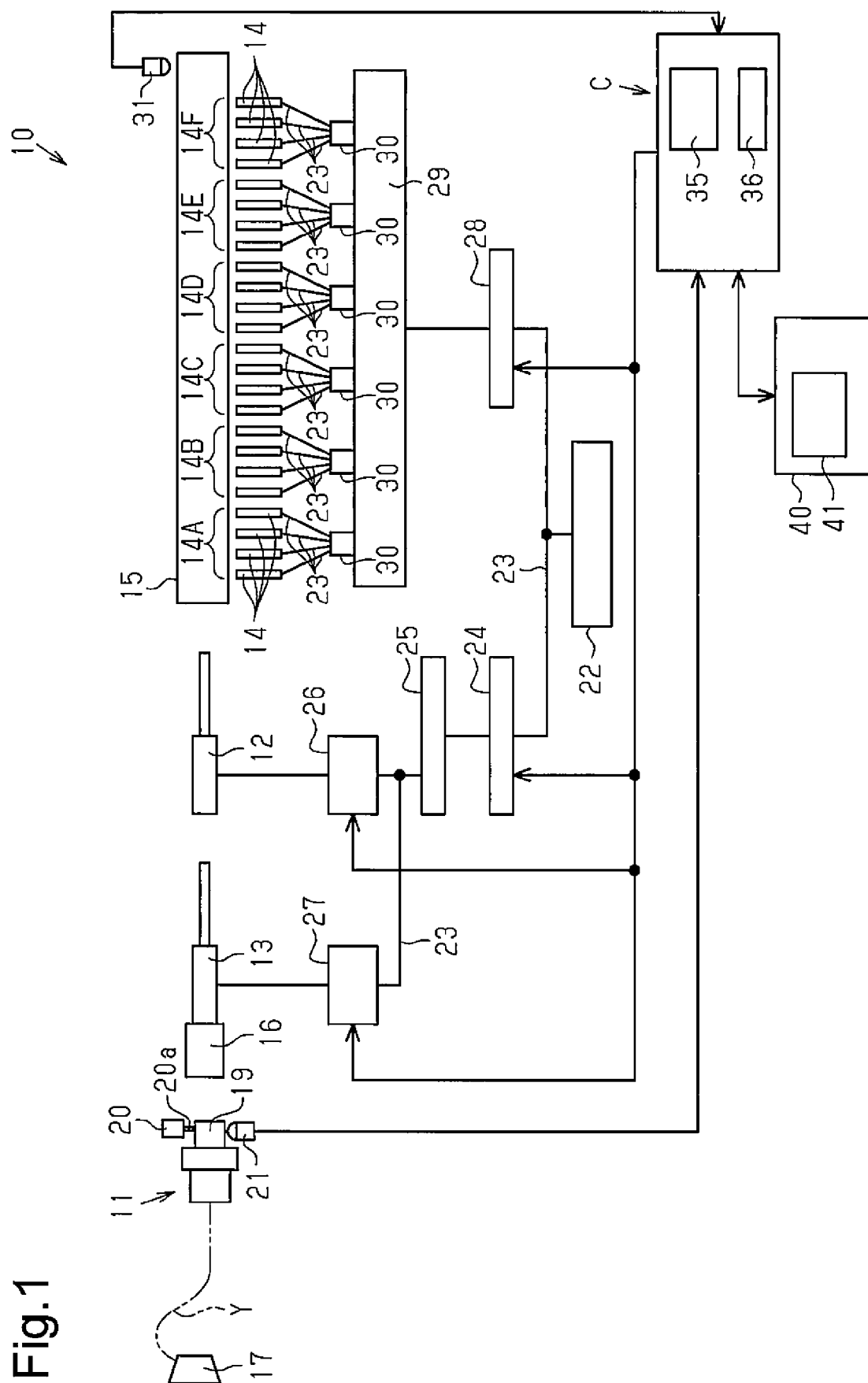


Fig.2

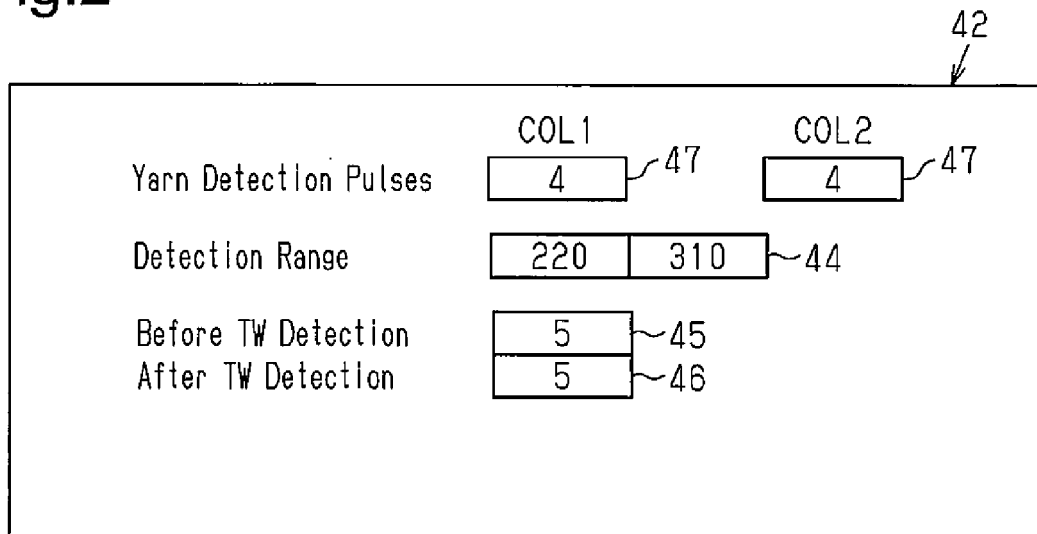


Fig.3A

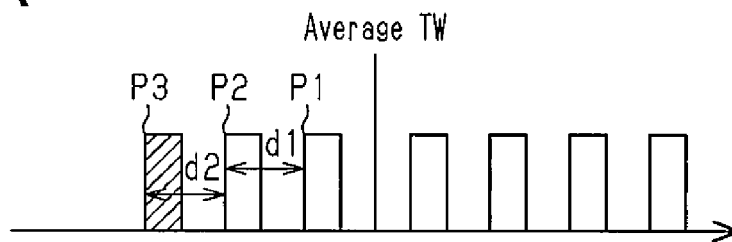


Fig.3B

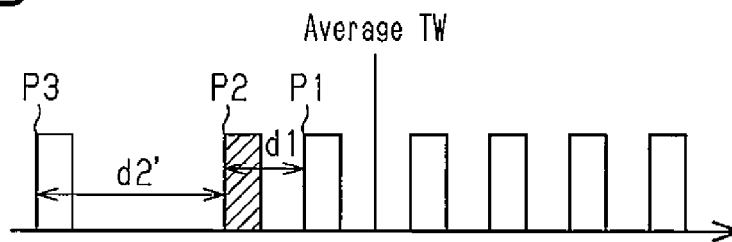


Fig.3C

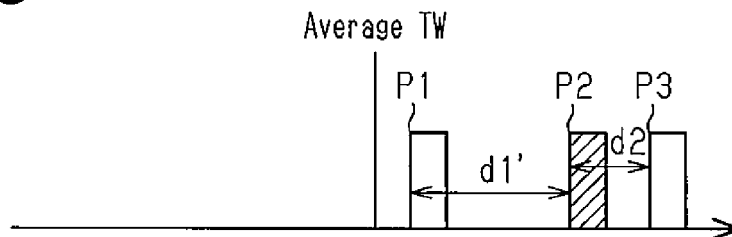


Fig.4

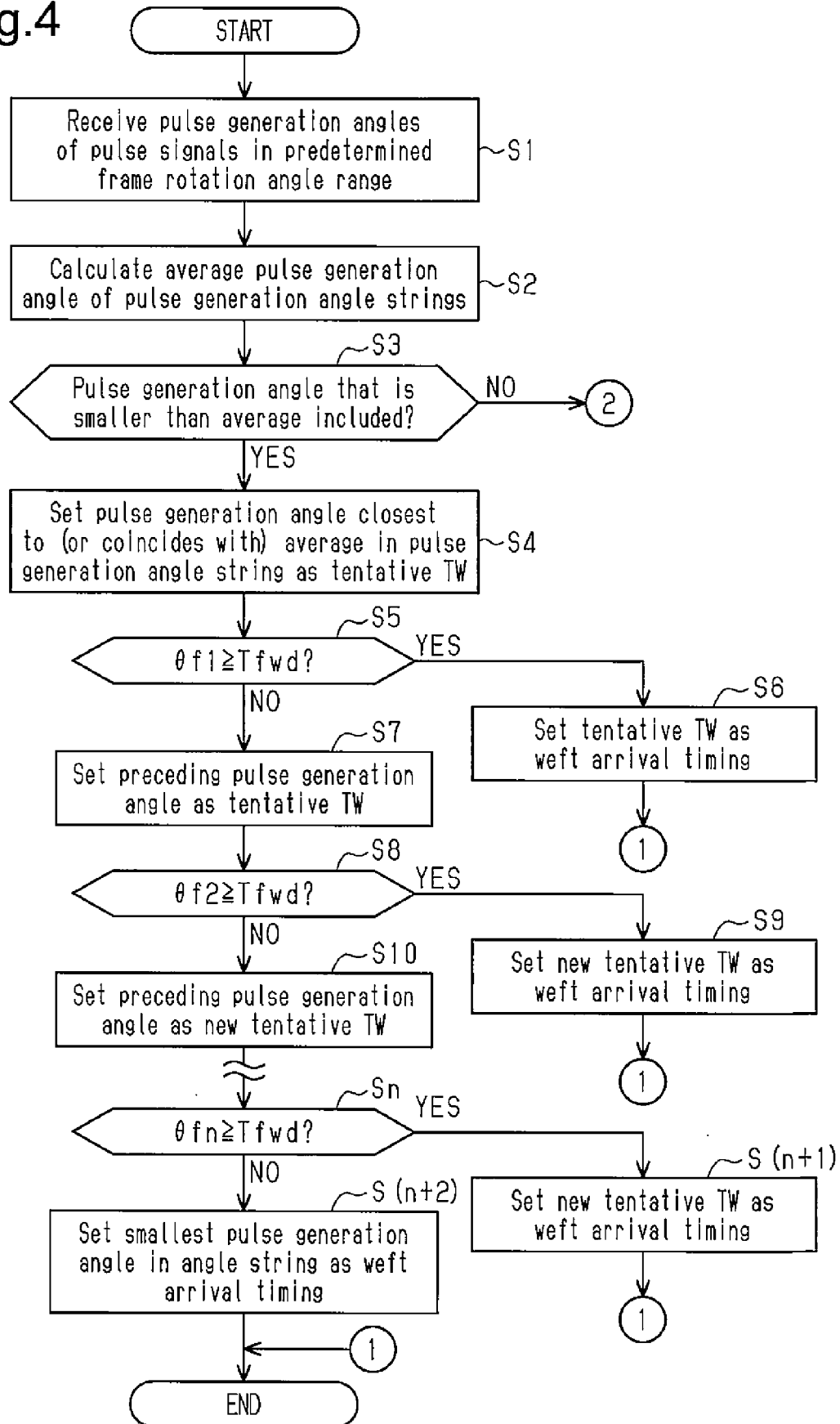


Fig.5

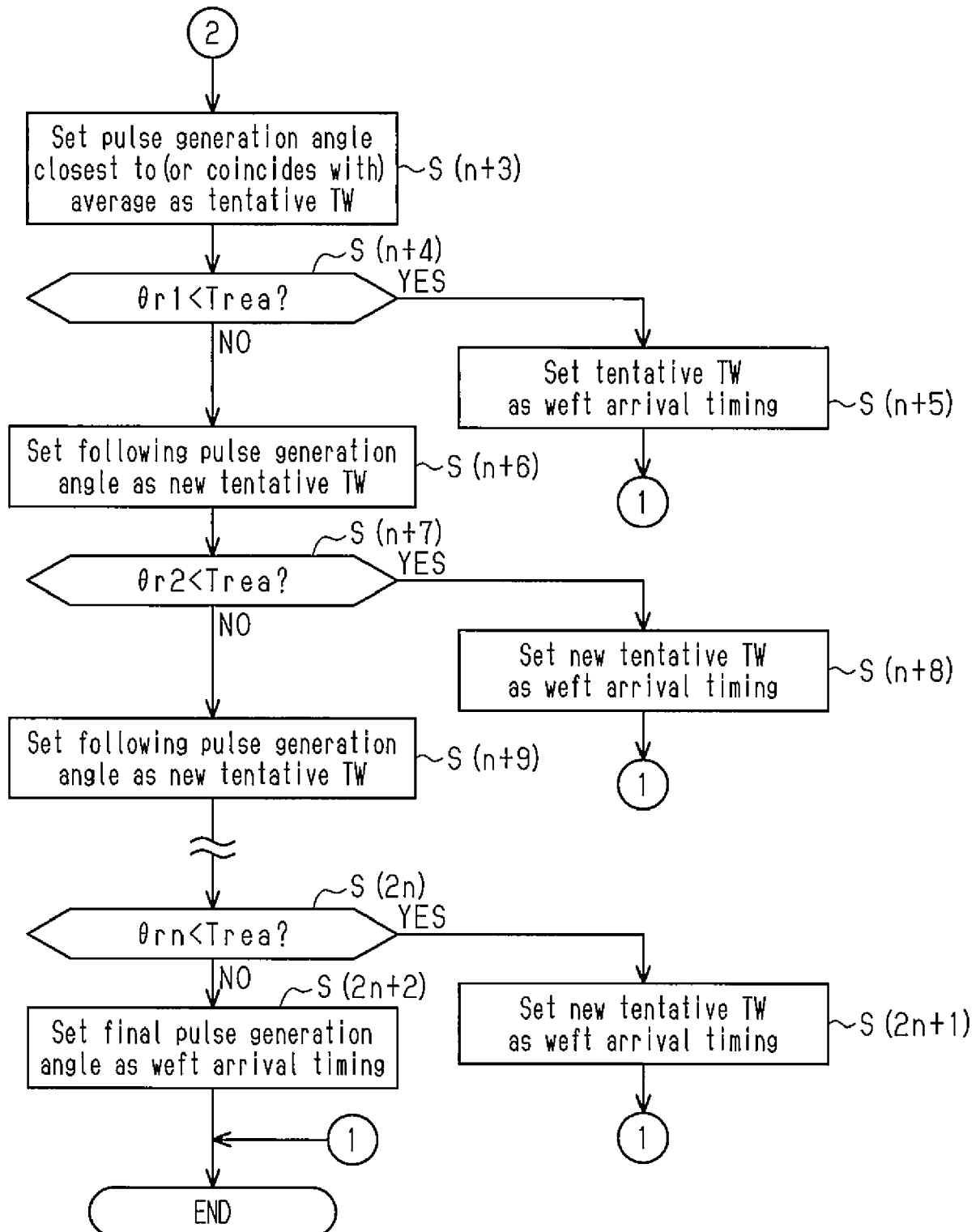


Fig.6

Pick No.	Pulse Generation Angle									
1	250	254	255	259	263	267	273	279	284	291
2	247	250	251	254	256	258	259	262	266	273
3	242	246	252	254	257	259	262	266	272	284
4	244	247	252	258	259	262	265	269	276	284
5	240	243	245	248	250	254	257	261	264	270
6	244	248	250	252	256	258	260	265	269	286
7	247	249	252	255	256	258	259	262	266	276
8	246	250	255	261	266	274	284	290	292	297
9	244	248	249	253	256	260	266	272	289	293
10	237	239	241	245	246	250	254	255	258	262
11	238	242	246	248	250	254	257	260	264	270
12	242	245	250	253	255	258	263	266	270	277
13	246	249	254	256	258	259	260	262	265	273
14	244	247	250	252	254	258	260	264	267	270
15	216	219	243	246	252	256	259	260	262	263
16	250	254	256	259	260	262	266	268	271	275
17	250	254	259	260	261	262	265	272	276	282
18	240	244	248	249	251	254	258	261	265	272
19	240	243	248	253	256	260	266	274	283	289
20	246	250	253	255	256	258	259	262	265	268
21	244	246	248	251	253	255	256	259	263	267
22	240	243	246	247	248	251	255	258	260	262
23	246	249	250	253	255	257	258	260	262	267
24	248	251	254	258	259	260	264	268	273	279
25	246	250	254	256	259	265	269	275	281	283
26	246	247	249	250	256	256	259	262	265	269
27	240	243	244	249	252	256	261	263	267	274
28	243	244	247	250	252	254	258	262	266	274
29	241	243	246	251	251	255	258	262	265	268

Fig.7A

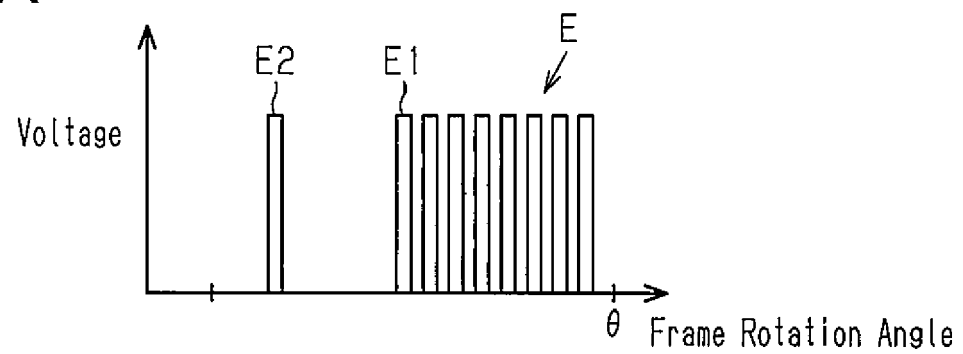
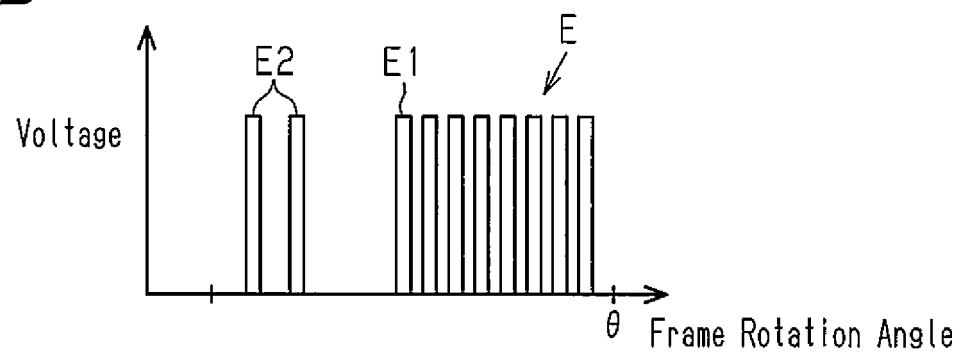


Fig.7B



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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